MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2022/2023

EME4066 – OPERATIONS RESEARCH

3 JULY 2023
9.00 a.m. – 11.00 a.m.
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This exam paper consists of **5 pages** including the cover page with **four questions** only.

2. Answer **ALL** questions. All necessary working steps must be shown.

3. Write all your answers in the answer booklet provided.

Please answer ALL questions and show the necessary working. Total mark is equal to 100.

Question 1 (30 marks)

Consider the following linear programming problem:

max $z = 2x_1 + 7x_2 - 3x_3$

s.t.

$x_1 + 3x_2 + 4x_3 \leq 30$

$x_1 + 4x_2 - x_3 \leq 10$

$x_1, x_2, x_3 \geq 0$

Let s_1 and s_2 be the slack variables for the respective constraints. After applying the simplex method, a portion of the final simplex tableau is given in Table 1.

Table 1: Final Simplex tableau

	Coefficient of						
BV	Z	x_1	x_2	x_3	s_1	s_2	RHS
Z	1				0	2	
	0				1	-1	
	0				0	1	

a) By using the revised simplex method (fundamental insight of the simplex method), identify the missing numbers and fill up the blanks in Table 1. (11 marks)

b) Write down the optimal solution based on a). (2 marks)

c) Write the dual of the linear programming model. (5 marks)

d) Write the dual optimal solution. (2 marks)

e) Now, conduct sensitivity analysis by independently investigating each of the following changes in the original model. **Then, test for feasibility and optimality. If either test fails, do not re-optimize.**

i) Change the right hand side to $\begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} 20 \\ 30 \end{bmatrix}$. (5 marks)

ii) Change the coefficients of x_3 to $c_3 = -2$, $a_{13} = 3$ and $a_{23} = -2$. (5 marks)

Continued...

Question 2 (25 marks)

Consider the transportation problem where products are shipped from sources O1, O2 and O3 to destination D1, D2, D3 and D4. The costs (in RM) per unit shipping from each sources to each destination, are listed in Table 2. The goal of the transportation problem is to decide on how to route its products to minimize the transportation cost.

Table 2: Transportation cost data

Manufacturing plant	Destination				Supply
	D1	D2	D3	D4	
O1	3	1	7	4	300
O2	2	6	5	9	400
O3	8	3	3	2	500
Demand	250	350	400	200	

a) Find the initial solution and the cost using the
   i) Northwest Corner method (3.5 marks)
   ii)VAM method. (5.5 marks)

b) By using the northwest corner method as the initial solution, find the solution by using the MODI method after **two** iterations. Is the solution optimal? (16 marks)

Question 3 (25 marks)

a) Company XYZ is selling its product through 5 agencies situated in different cities (A, B, C, D and E). Recently there was a sudden demand for the product in 5 more cities (I, II, III, IV and V) that do not have any agency of the company. The company is deciding on how to assign the agencies to dispatch the products to these 5 different cities (I, II, III, IV and V) in such a way that the travelling distance is minimized. The distances in km between the cities are given in Table 3. Use the Hungarian method to solve this assignment problem.

Table 3: Distance (in km) between the cities

	Cities				
Cities	I	II	III	IV	V
A	160	130	175	190	200
B	135	120	130	160	175
C	140	110	155	170	185
D	50	50	80	80	110
E	55	35	70	80	105

(12 marks)

Continued...

b) An agricultural company wants to decide which commodity should stock to get maximum profit. It was supplied with the following information. The probability that the monsoon will **be excess, normal and deficient is 0.40, 0.30 and 0.30.** The estimated profit (per 1 ton of commodity) of three commodities in respect of these different kinds of monsoon are given in Table 4.

Table 4: Profit (per ton) of commodities to states of nature

	States of Nature		
Commodity	Excess	Normal	Deficient
Rice	10000	-4000	15000
Wheat	4000	-3000	8000
Maize	4000	1000	-1000

Determine the optimal decision under each of the following decision criteria and show how you have arrived at it:

i) Maximax (2.5 marks)
ii) Maximin (2.5 marks)
iii) Minimax regret (5.5 marks)
iv) Equal Likelihood Criterion (2.5 marks)

Question 4 (20 marks)

a) A cafeteria in MMU runs as a self-service facility in which students select the food items they want and then form a single line to pay the cashier. Students arrive at a rate four per minute in average according to a Poisson distribution. The cashier takes on average 12 seconds to serve one student at the counter following an exponential distribution.

i) What is the probability that there are more than 2 students in the system? (4 marks)
ii) How long on average a student have to wait before reaching the cashier? (2 marks)
iii) What is the average number of students in the queue? (2 marks)
iv) If a second cashier is added (who works at the same pace), what is the probability that the system is empty? Assume that students wait in a single line and go to the first available cashier. (Hint: $P_0 = \frac{1}{\left[\sum_{n=0}^{n=s-1}\left[\frac{1}{n!}\right]\left[\frac{\lambda}{\mu}\right]^n\right]+\left[\frac{1}{s!}\right]\left[\frac{\lambda}{\mu}\right]^s\left[\frac{s\mu}{s\mu-\lambda}\right]}$) (2 marks)

Continued...

b) The Morris Machine company received an order to refurbish five motor for materials handling equipment that were damaged in a fire. The motors will be repaired at two workstations in the following manner.
Workstation 1: Dismantle the motor and clean the parts
Workstation 2: Replace the parts as necessary, test the motor, and make adjustments.
All motors need to go through workstation 1 before it is delivered to workstation 2. The estimated time to repair each motor is shown in Table 5.

Table 5: Time (hour) to repair the motors

	Time (hour)	
Motor (Job)	Workstation 1	Workstation 2
M1	12	22
M2	4	5
M3	5	3
M4	15	16
M5	10	8

i) Using Johnson's rule, find the order of jobs processed in the machines. (1 mark)

ii) Draw a Gantt chart stating clearly the starting time and ending time of each job (motor) in both the workstations (inclusive of idle time). (6 marks)

iii) How long does it take to complete repairing all 5 motors? (1 mark)

iv) What is the total idle time? Show the calculation. (2 marks)

End of Page.